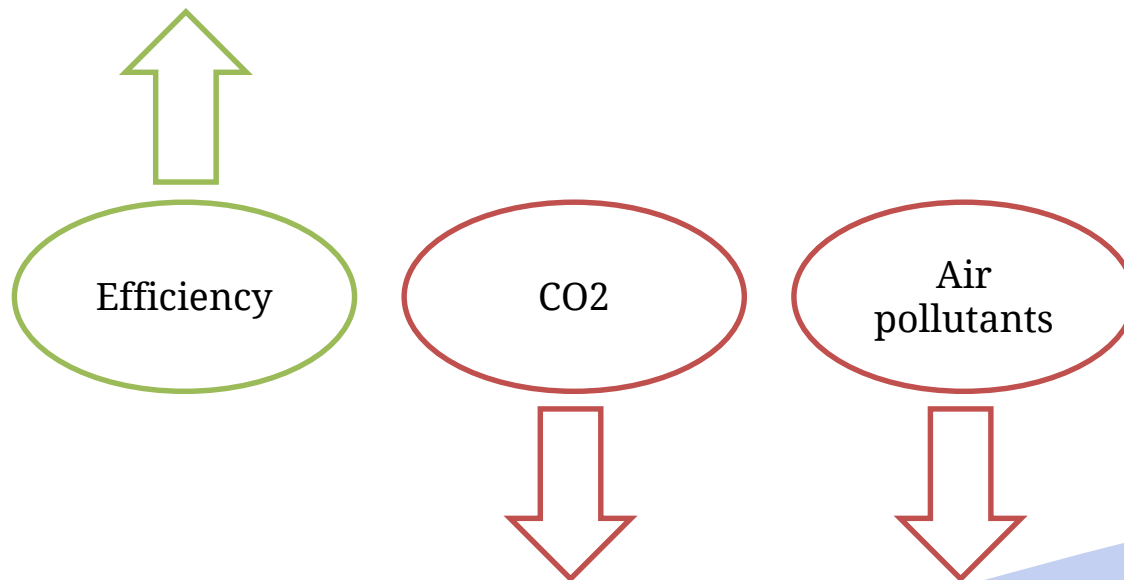


Overview of alternative energy carriers for inland navigation

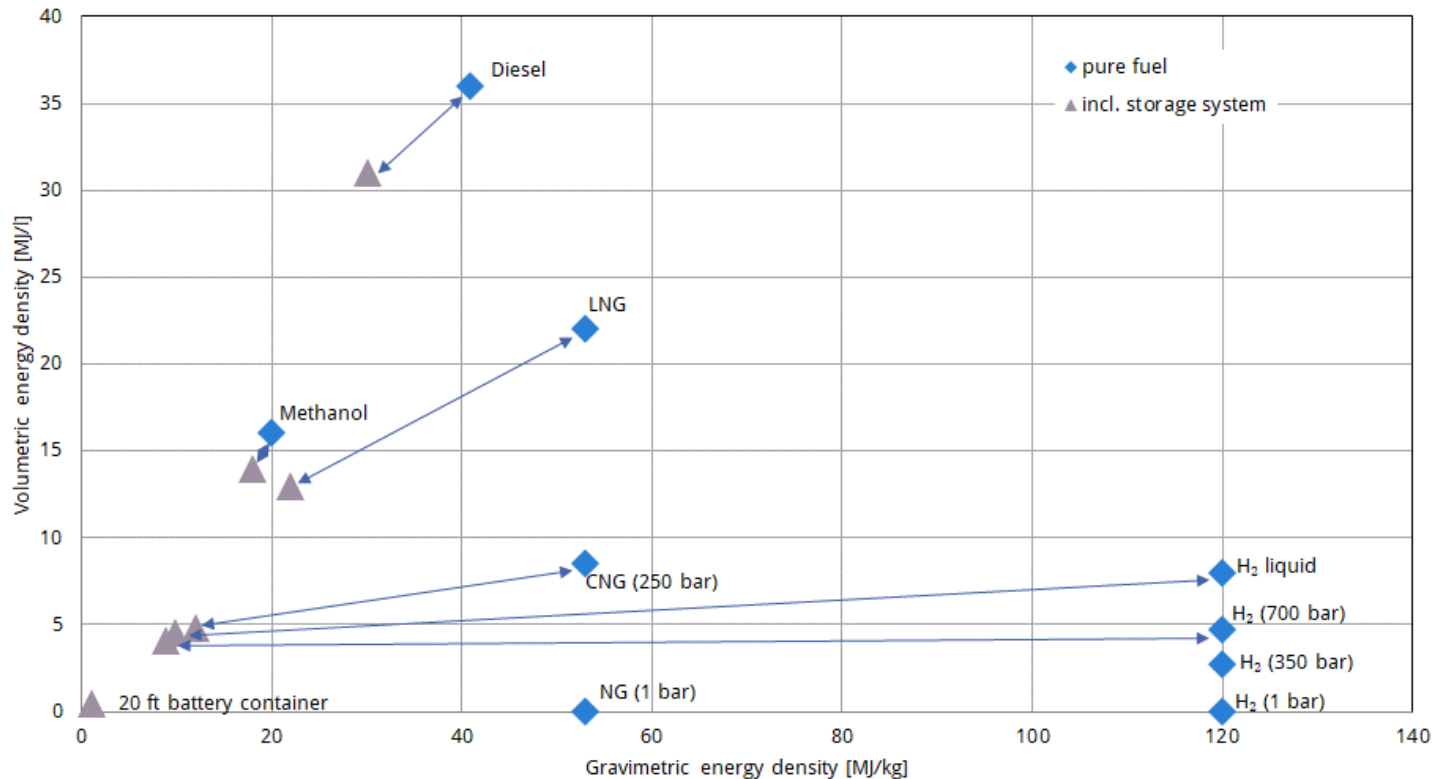
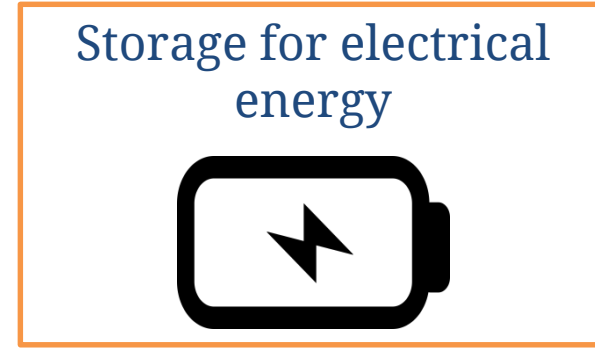
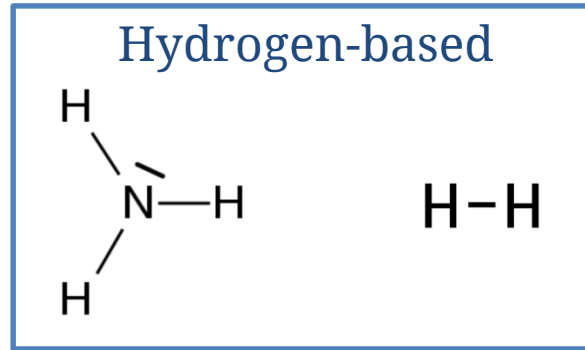
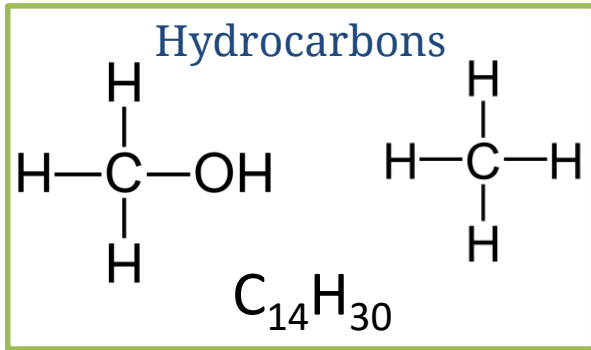
Friederike Dahlke-Wallat

Development Centre for Ship Technology and Transport
Systems (DST e.V.)

- Climate change challenge and agreed policy
- Energy turnaround also for inland navigation to achieve long-term climate objectives



Energy Carriers



Diesel and diesel-electric propulsion

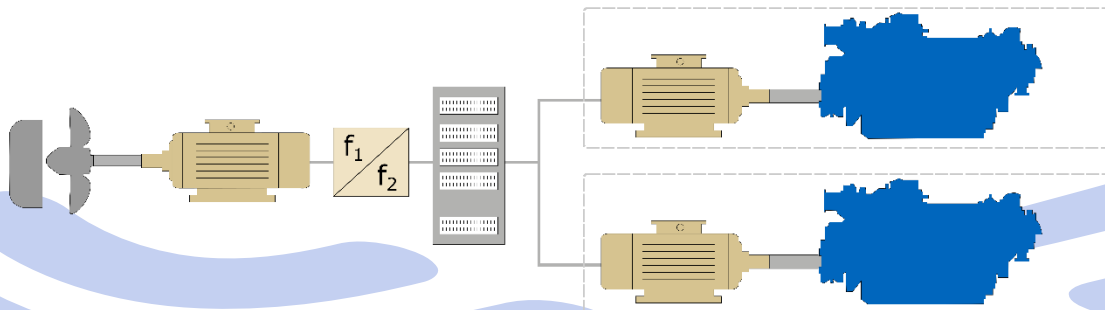
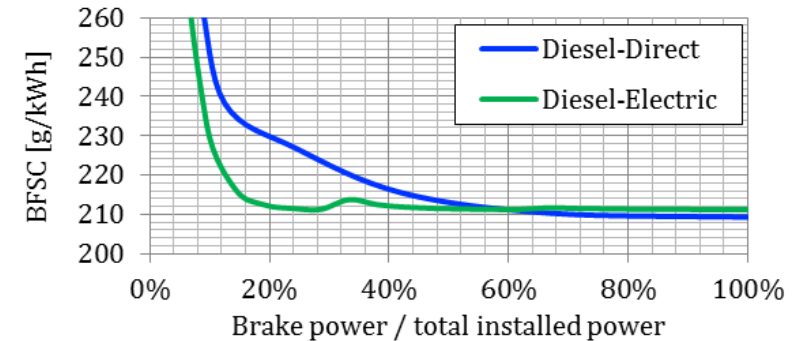
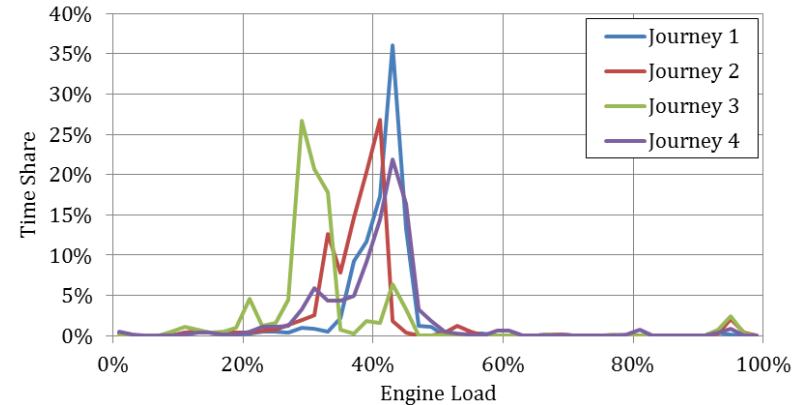


BENEFITS

- Engines running in their sweet spot
- Low noise and reduced vibrations
- Increased efficiency for suited operational profiles
- More flexibility to generate auxiliary energy
- Easier implementation of batteries and fuel cells
- Additional freedom for engine positioning
- Trend to better manoeuvrability
- Highly redundant designs possible

DOWNSIDES

- Additional losses
- Higher weights
- Increased space requirements
- Higher investment costs



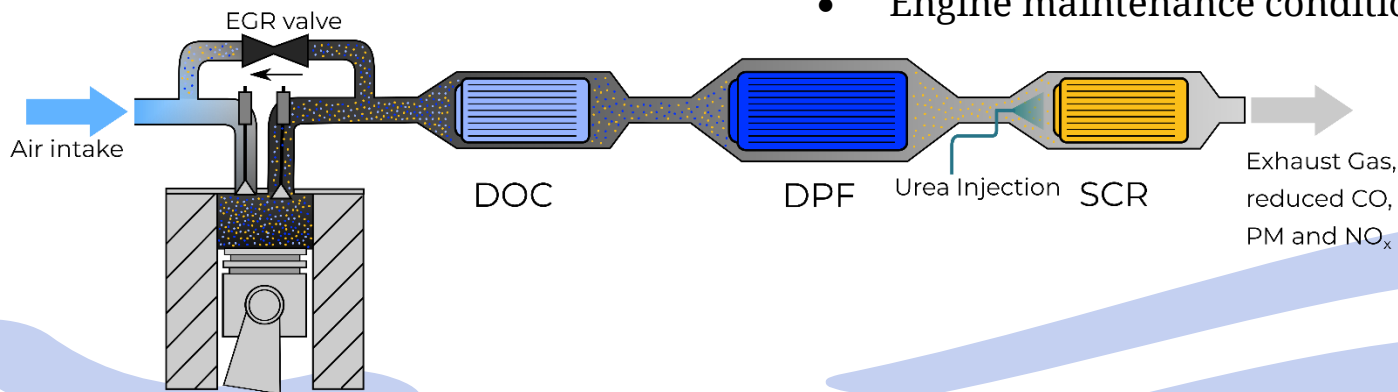
Aftertreatment

- Exhaust Gas Recirculation: NO_x ↓
- Diesel Oxidation Catalyst (DOC): HC, CO ↓
- Diesel Particulate Filter (DPF): PM ↓
- Selective Catalyst Reduction (SCR) NO_x ↓

AFTER-TREATMENT DESIGN

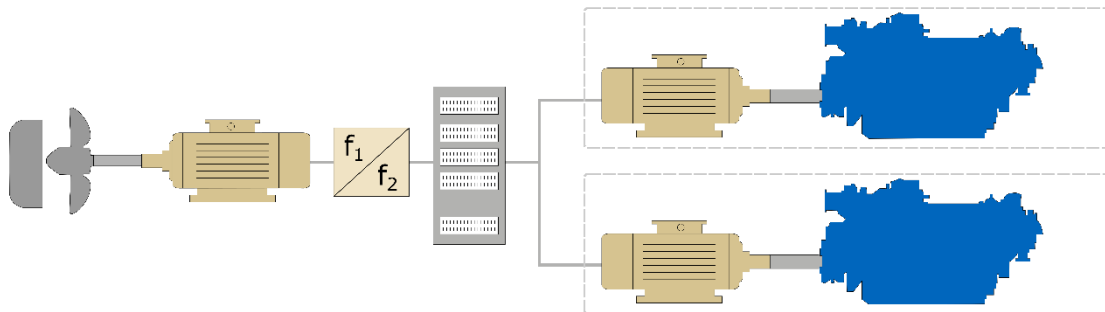
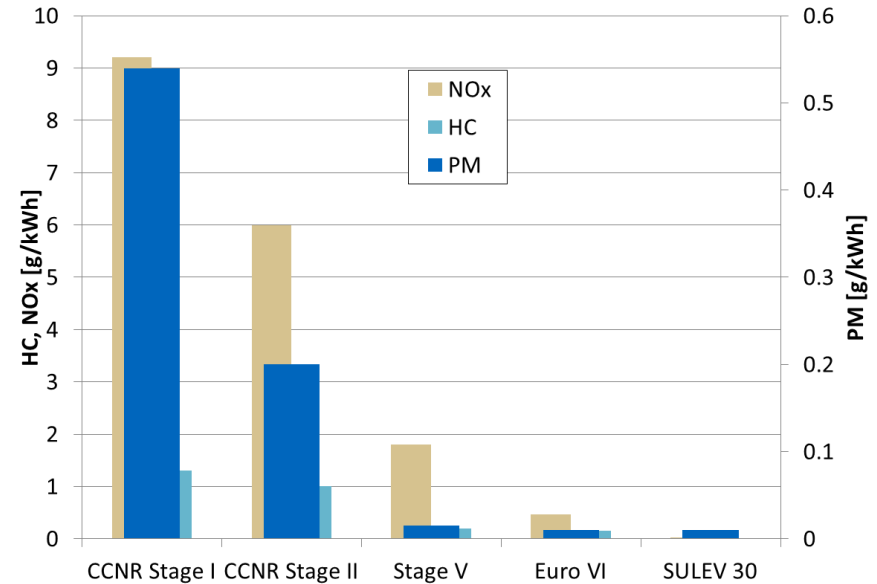
The design of after-treatment systems depends on prerequisites like:

- Exhaust gas temperature
- Allowable back pressure of the engine
- Operational profile (e. g. operational hours)
- Available space in engine room or on the deck
- Mass flow rate of exhaust gas
- Engine maintenance condition



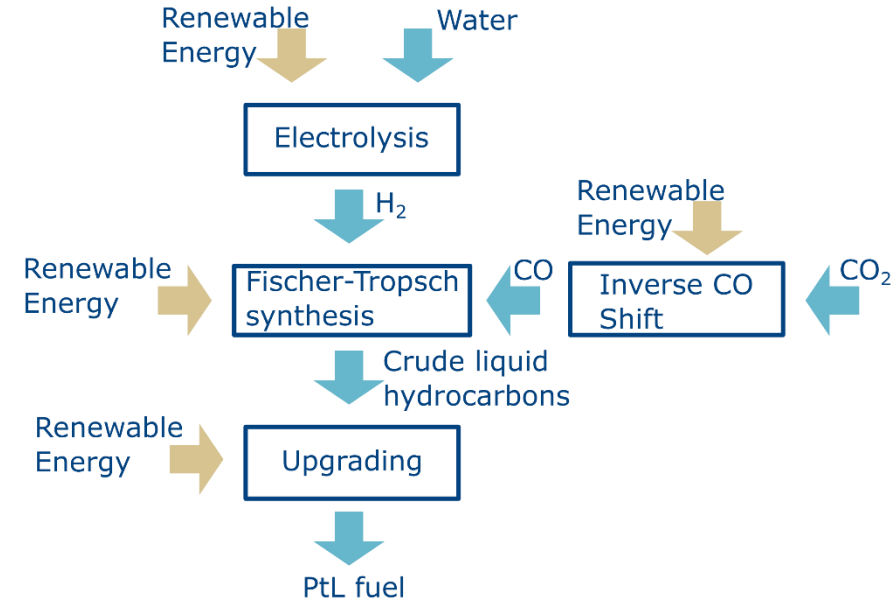
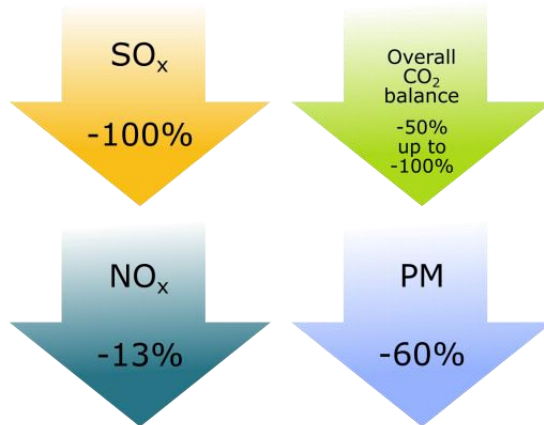
Euro VI and NRE engines

- Marinisation required
- (blended) Diesel/Drop-In fuels
- Exhaust after treatment
- Direct and diesel electric drive



Drop-In (Bio) Fuels

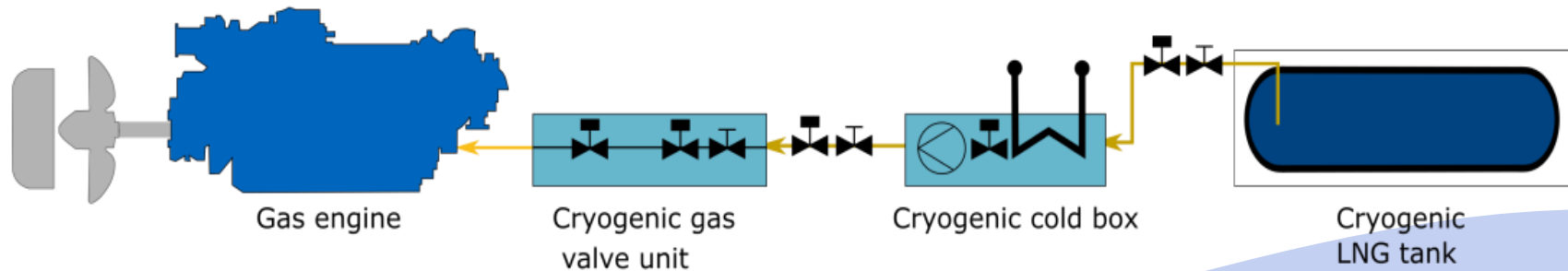
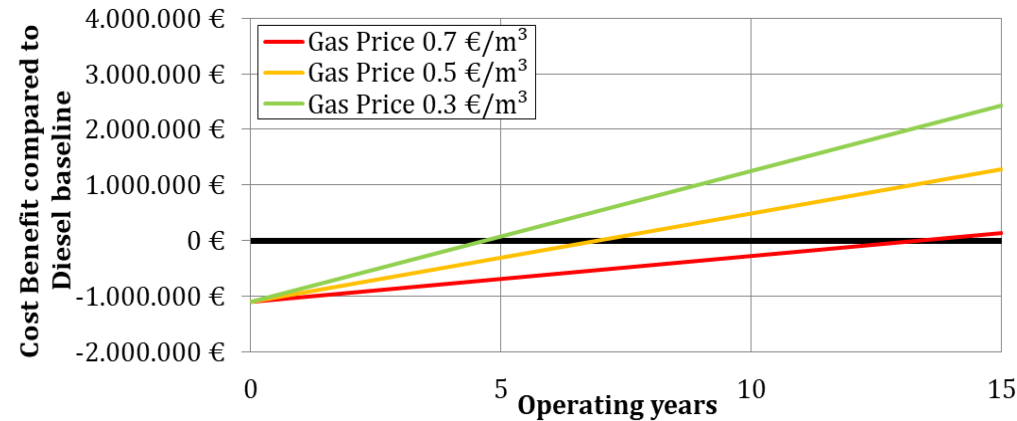
- Gas-to-Liquid (GTL), Biomass-to-Liquid (BTL), Power-to-Liquid (PTL)
- Hydrotreated-Vegetable-Oil (HVO)
- Synthetic fuels covered by EN15940
- Blends up to 100%



Gas and gas-electric propulsion

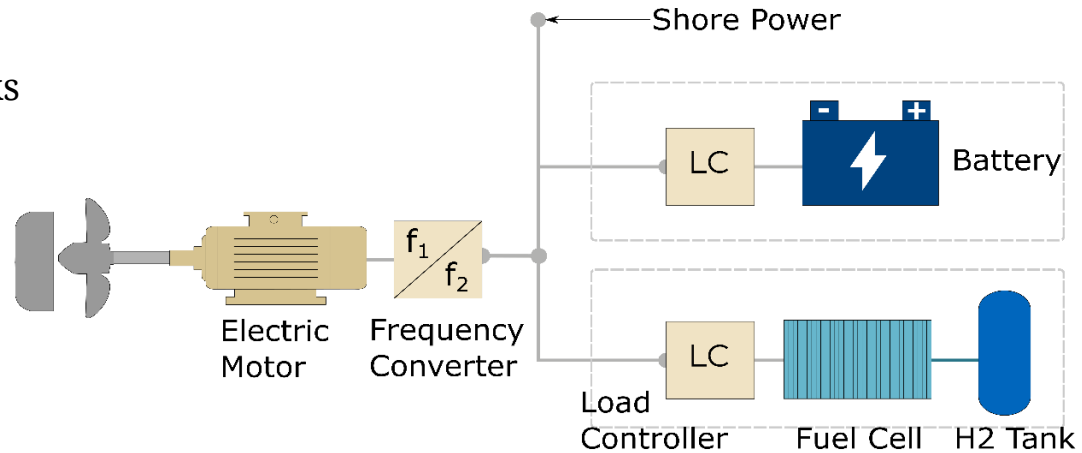


- From fossil sources or from biomass or from renewable energy (Power-to-Gas)
- LNG in cryogenic pressure tanks
- CNG as option for moderate energy demand



Fuel Cells

- Hydrogen
 - Liquid in cryogenic tanks
 - Compressed
- Other energy carriers
 - Methanol
 - LOHC
 - Methane
 - Ammonia

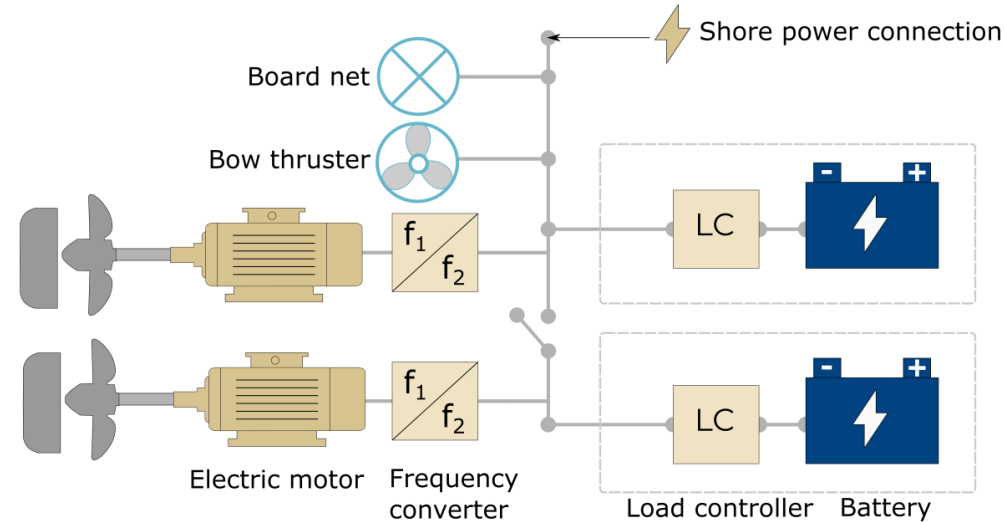


BENEFITS	DOWNSIDES
<ul style="list-style-type: none"> • High efficiency at full load and (depending on application) at partial load • Good controllability • Good performance extension due to modular design • High development potential 	<ul style="list-style-type: none"> • High investment costs • Operating experience in field test still low • Shorter useful life compared to market-dominating products (combustion engine) • Few suppliers

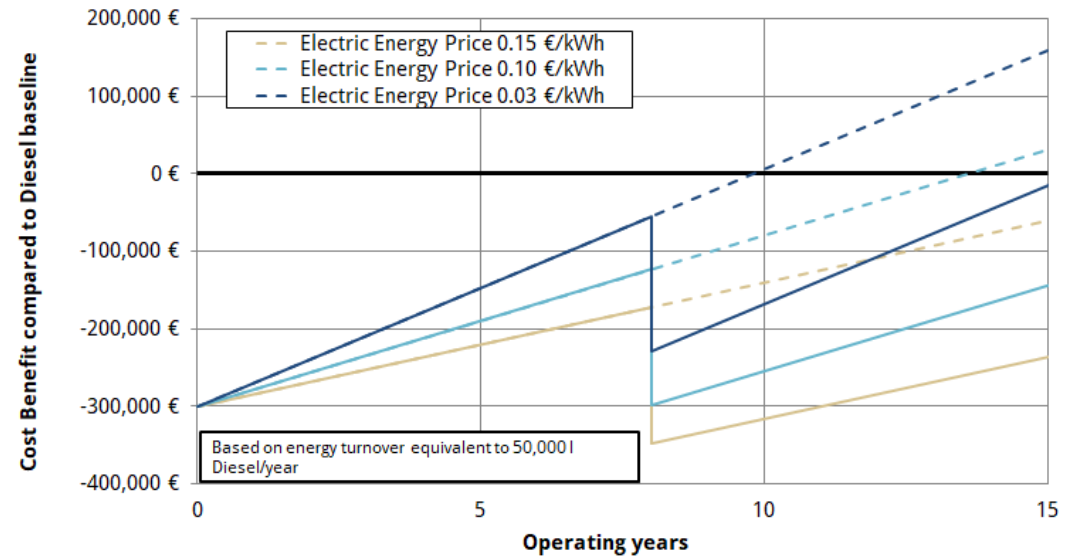


Battery-Electric propulsion

- Charging on board or ashore
- Infrastructure for charging or exchange of battery containers
- Own battery or “energy-as-a-service”
- Good for peak shaving and local emission reduction



Source: Zero Emission Services B.V. (ZES)



Conclusion



- Aims for 2035 and 2050 → Price development of technologies
- Preparations for energy turnaround on the Danube should start now
- Creation of financial instruments
- Selection of regionally appropriate measures

Thank You!

**It's Not that Easy
Being Green**
By George Merrill

